

Issued June 14, 1913.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY, E. A. BIRGE, DIRECTOR; COLLEGE OF AGRICULTURE, UNIVERSITY OF WISCONSIN, H. L. RUSSELL, DEAN; A. R. WHITSON, IN CHARGE SOIL SURVEY.

SOIL SURVEY OF FOND DU LAC COUNTY,
WISCONSIN.

BY

W. J. GEIB, GUY CONREY, AND ARTHUR E. TAYLOR, OF THE
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MANN AND F. L. MUSBACK, OF THE WISCONSIN
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J. E. LAPHAM, INSPECTOR IN CHARGE NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1911.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., November 27, 1912.

SIR: In the extension of soil survey work in the State of Wisconsin work was undertaken in Fond du Lac County during the field season of 1911. This work was done in cooperation with the Wisconsin Geological and Natural History Survey, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this area and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1911, as provided by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SOIL SURVEY OF FOND DU LAC COUNTY, WISCONSIN.

By W. J. GEIB, GUY CONREY, and ARTHUR E. TAYLOR, of the U. S. Department of Agriculture, and LEROY SCHOENMANN and F. L. MUSBACK, of the Wisconsin Geological and Natural History Survey.

DESCRIPTION OF THE AREA.

Fond du Lac County is located a little to the south of the east-central part of the State of Wisconsin. It is bounded on the north by Winnebago and Calumet Counties and Lake Winnebago, on the east by Calumet and Sheboygan Counties, on the south by Washington and Dodge Counties, and on the west by Green Lake County. The county is 36 miles long and varies in width from $27\frac{1}{4}$ miles in the eastern one-third to 18 miles in the western two-thirds of the county. It has an area of approximately 734 square miles, or 469,760 acres. The east county boundary is from 19 to 23 miles from Lake Michigan.

The most pronounced topographic feature in the county is an escarpment of Niagara limestone, which extends across the area from northeast to southwest. It first appears about $1\frac{1}{2}$ miles south of Pipe, extending southward to a point about 7 miles below Taycheedah, where it swings westward past Hamilton and on to Oakfield, passing out of the county to the southwest. It is not continuous

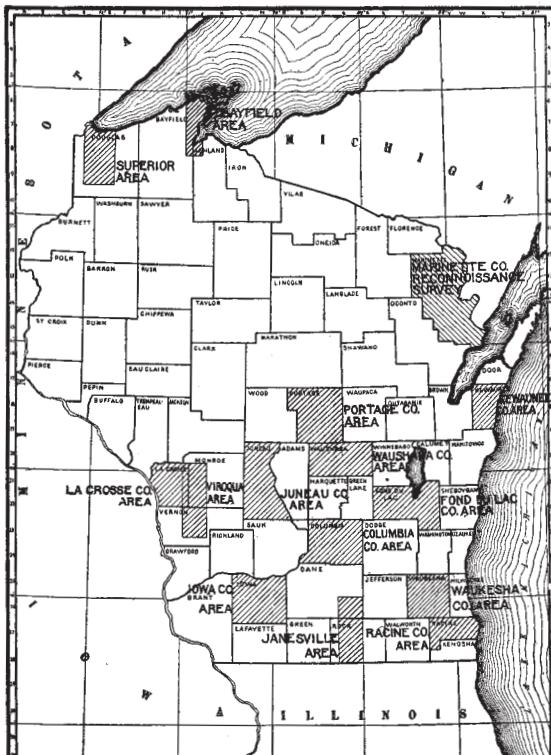


FIG. 1.—Sketch map showing areas surveyed in Wisconsin.

throughout its course, although there are unbroken stretches of several miles. This escarpment varies in elevation from 50 to 150 feet above the general level of the country below. Fond du Lac, which is situated but a short distance from the foot of the escarpment, has an elevation of 760 feet above sea level.

To the east of the escarpment the surface is higher and more rolling than to the west. The Kettle Moraine crosses the southeastern part of the county, and throughout this region the topography is rolling to hilly, with numerous kettle holes, gravelly ridges, and other evidences of glacial action. North of this section the surface is gently rolling to rolling, with numerous drumlins and a few level areas of relatively small extent.

Immediately to the west of the escarpment is a large flat area of excellent soil, at one time occupied by an extension of Lake Winnebago. This extends southward to within a few miles of the county line. Between this old lake basin and the west county line is another extensive area of excellent farming land. The surface varies from nearly level to undulating and gently rolling. A large proportion of this region was originally prairie land, and has a rich black soil, while the remainder consists of a light-colored soil, formerly carrying a good stand of timber. Numerous marshes, varying in size from a few acres to over 10 square miles in extent, are scattered throughout the county both east and west of the escarpment.

The drainage of the county is somewhat unusual in that a number of fair-sized rivers have their headwaters within its boundaries. The greater proportion of the eastern part of the survey above the escarpment drains into Lake Michigan through the South Branch of Manitowoc River, Sheboygan River, and the West and Middle Branches of Milwaukee River. All of these streams rise in the county. The stretch of level country in the central part of the area, extending from Fond du Lac nearly to Oak Center, drains through the East Branch of the Fond du Lac River into Lake Winnebago. The West Branch of the Fond du Lac River drains the north-central part of the county. A few smaller streams flow directly into Lake Winnebago and drain a narrow margin along the east and west shores of the lake. The extreme northwestern corner is drained by Silver Creek and the west-central part by Grand River, both of which empty into the Fox River, and thence into Lake Winnebago. The headwaters of Rock River drain the southwestern and south-central parts of the county. This stream flows into the Mississippi River, and the region drained by it is the only part of Fond du Lac County whose drainage waters do not finally reach Lake Michigan.

The first settlement in the county was made on the present site of Fond du Lac in 1836. Farming operations started in Fond du Lac

Township in 1837 and in Waupun in 1839. The real settlement of the county, however, began in 1844-45, when many farms were opened up.

Some of the early settlers were French from Canada, many came from New England and other eastern States, while some came directly from European countries. In the southeastern part of the county Germans and Irish predominate at the present time. In the vicinity of Eden and to the east the Irish are the most numerous. In the northeastern part Germans and a few French are found. The central and western parts of the survey are settled mostly by descendants of German families. All portions of the county are well settled and highly developed agriculturally.

Fond du Lac, with a population of 18,797, is the largest city in the area, the county seat, an important railroad point, and a prominent manufacturing center. It is situated at the southern end of Lake Winnebago and is surrounded by an excellent farming country. Ripon, in the northwestern corner of the county, with a population of 3,739, is located in the center of a rich agricultural region and is a thriving, modern town. Waupun, in the southwestern part of the county, has a population of 3,362, is surrounded by excellent farming land, and is the center of a highly developed community. Brandon, Oakfield, Oak Center, Campbellsport, Eden, Rosendale, Vandyne, Fairwater, and St. Cloud are smaller towns and villages.

Three important railroad systems traverse the county and provide excellent transportation facilities for all sections. The main division of the Soo Line (Wisconsin Central) from Chicago to Duluth crosses the area from north to south, passing through Vandyne, Fond du Lac, Hamilton, and Byron. A main line of the Chicago & Northwestern from Chicago and Milwaukee to points in northern Michigan and northern Wisconsin crosses the county, passing through Campbellsport, Eden, Fond du Lac, and Vandyne. The Chicago & Northwestern from Sheboygan to Grand Rapids and Marshfield traverses the county from east to west. St. Cloud, Calvary, Malone, Silica, Peebles, Taycheedah, Fond du Lac, Rosendale, El Dorado, and Ripon are situated along this line. Another branch of the Chicago & Northwestern from Fond du Lac to Janesville extends to the southwest from Fond du Lac through Oakfield and Oak Center. From Iron Ridge, on the northern division of the Chicago, Milwaukee & St. Paul Railroad, a branch extends north to Fond du Lac, and from Horicon Junction another branch goes north through Waupun, Brandon, and Ripon, from which point connection is made with Oshkosh and Winneconne, in Winnebago County. From Brandon a short spur extends west through Fairwater and on to Markesan, in Green Lake County. Fond du Lac has water connection with points on

the Great Lakes through Lake Winnebago, the Fox River, and Green Bay, though the large lake boats can not come into Lake Winnebago. This makes the use of smaller boats necessary from Green Bay to Fond du Lac.

Fond du Lac and the other towns within the area provide a market for considerable farm produce and supply shipping points from which large quantities of produce reach outside markets. Chicago, over the Soo Line, is 159 miles, and Milwaukee, over the Northwestern, 63 miles distant.

Most of the wagon roads throughout the county are graded, and many miles are surfaced with crushed rock and gravel. As a whole the public highways are kept in very good condition. All parts of the county have rural free-delivery mail service, and telephones are in common use throughout the country districts.

CLIMATE.

The climatic conditions which prevail in Fond du Lac County are representative of a large section in the east-central part of the State, where agriculture is highly developed and where extremes of climate do not prevent the growing of any of the general farm crops.

The mean annual temperature is 44.6°, the maximum 102°, and the minimum -44°. The average rainfall is 27.84 inches, which, under normal conditions, is well distributed throughout the growing season. The months of May, June, July, and August, during which the crops are most in need of a good supply of moisture, have an average of more than 3 inches of rainfall.

While there is a wide range in the temperature, the extremely low and high readings recorded are rare and the periods affected are of short duration. The winters are usually severe and there is an average snowfall of 28.7 inches. The prevailing winds are from the southwest, and thunderstorms are of frequent occurrence during the summer.

The average date of the last killing frost in the spring is May 5 and of the first killing frost in autumn October 2, giving an average growing season of 150 days.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation as recorded by the Weather Bureau station at Fond du Lac and covering a period of years from 1886 to 1909:

Normal monthly, seasonal, and annual temperature and precipitation at Fond du Lac.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
December.....	*F. 21.8	*F. 57	*F. -27	Inches. 1.48	Inches. 1.44	Inches. 1.10
January.....	17.0	54	-44	1.30	1.34	2.36
February.....	17.9	56	-30	1.13	0.34	2.00
Winter.....	18.9	.....	.....	3.91	3.12	5.46
March.....	31.0	75	-16	1.63	0.49	0.82
April.....	44.5	87	-5	2.24	0.97	1.79
May.....	56.1	91	23	3.24	2.45	6.86
Spring.....	43.8	.....	.....	7.11	3.81	9.47
June.....	66.0	96	31	3.53	0.09	8.31
July.....	70.0	102	40	3.53	2.15	4.56
August.....	67.7	100	35	3.44	3.19	1.59
Summer.....	67.9	.....	.....	10.20	6.03	14.46
September.....	61.2	96	22	2.86	1.05	2.46
October.....	48.5	89	8	2.05	0.31	1.03
November.....	33.7	68	-14	1.71	1.17	1.46
Fall.....	47.6	.....	.....	6.62	2.53	4.95
Year.....	44.6	102	-44	27.84	15.59	34.34

AGRICULTURE.

Agriculture in the county dates back to 1837, when the first furrow was turned on the present site of Fond du Lac. Farming operations were started in the spring of 1839 at Waupun and five years later agricultural development was well under way in various parts of the county.

For many years wheat was the dominant crop, winter wheat being sown in the "openings," where there was more protection, and spring wheat on the prairies, from which the severe winds of winter blew the snow. After a few years winter wheat was almost entirely abandoned, and for a period of 25 years spring wheat was the leading crop. About this time the chinch bug, weevil, droughts, and lower yields somewhat discouraged the growing of spring wheat, and winter wheat came into favor again. Since then both winter and spring wheat have been grown, with the spring wheat in the lead, but the acreage devoted to this crop has rapidly decreased until at present there is less than 1,600 acres in wheat in the entire county.

Little attention was paid to rotation of crops during the early days, the same crop being grown on the land year after year until it was finally abandoned and new land taken up. As wheat growing declined corn was planted, and a more diversified system of agriculture resulted. Dairying gradually replaced wheat, and in 1870 the first dairyman's association in the State was formed. A cheese factory was erected in 1864. It is largely to dairy farming that the present prosperous condition of the region is due.

The type of agriculture most largely followed throughout the county at present is dairying, in conjunction with general farming and stock raising. The four leading crops of the area in the order of their acreage are oats, hay, barley, and corn. Wheat, potatoes, alfalfa, rye, and a number of special crops are also grown, though much less extensively.

In 1909 the oat crop occupied an area of 72,551 acres, from which an average yield of slightly over 40 bushels per acre was obtained. In 1875 there were 21,966 acres, and in 1905 there were 62,325 in this crop. The Miami silt loam produces more oats than any other type of soil. Some of the crop is sold, but the greater part is fed to stock on the farms.

Hay is the second crop in point of acreage. The 71,031 acres in grass in 1909 was made up of about 40 per cent of mixed timothy and clover, 25 per cent of timothy alone, 7 per cent clover alone, 20 per cent marsh hay, with the remainder in alfalfa, other tame grasses, and forage crops. The average yield of hay was 1.8 tons. Alfalfa is proving successful. From the 1,623 acres reported in this crop in 1909 an average yield of nearly 3 tons per acre was secured.

Barley is the third crop in importance in the area, 49,027 acres in 1909 yielding an average of 30.4 bushels per acre. The tendency at the present time seems to be to reduce the acreage given to this crop. During the early history of the region barley was not grown as extensively as wheat, oats, or corn, and in 1875 there were only 4,494 acres devoted to the crop. While some of the grain is fed on the farm the greater proportion is sold, and it may be considered the only cash crop grown extensively in the county.

Not as much corn is planted as one expects in a section where the dairy industry has been so highly developed. In 1909 there were 39,930 acres in this crop. The average yield for the same year was 40.8 bushels an acre. A large part of the corn is cut for silage. Corn matures satisfactorily in this latitude, and considerable attention is being paid to selecting and breeding the most desirable varieties. The Carrington silt loam is better adapted to this crop than any of the other types, and a relatively large proportion of the type is devoted to it. Practically all of the corn grown, except that sold for seed, is fed on the farm where it is grown, some as silage, some

as a part of the grain ration for dairy cows and beef cattle; and a large part in fattening hogs.

The wheat harvested in 1909 from 1,581 acres averaged 21.4 bushels per acre. In 1875 there were over 90,000 acres in wheat, while in 1905 there were 3,285 acres. It is no longer an important crop, and there are some communities where it is scarcely grown at all. Of the amount raised at present about one-third is winter and two-thirds spring wheat.

Alfalfa is becoming an important crop, as its value as feed for dairy stock makes it a fine crop for this region. It has passed the experimental stage, and it is now recognized that it can be grown successfully in nearly all parts of the county. The average yield of hay is practically 3 tons per acre, three cuttings usually being obtained. Considerably higher yields are frequently secured, and four cuttings in a single season are not uncommon. An acid condition of the soil exists in some places, and this must be corrected before the best success can be attained with alfalfa.

A little rye is produced, but is confined chiefly to the sandy soils. In 1909 there were about 1,000 acres in rye, the average yield being 20 bushels per acre.

Potatoes are not grown on a commercial scale, except in the vicinity of Campbellsport, but many farmers produce more than are needed for home use, and the surplus is sold in the local markets. The acreage in potatoes in 1909 was 5,080 acres and the average yield about 168 bushels per acre.

Sugar beets are produced successfully on a number of different types of soil. Beets grown on the Miami silt loam have a slightly higher sugar content than those from the Carrington silt loam or the Clyde silty clay loam. Beets are grown more extensively on the first two types named than on any of the other soils of the county. Most of them are shipped to the factory at Menomonee Falls, Wis.

Peas for canning are grown extensively in the vicinity of Waupun, where a factory is located. Cabbage is also grown on a commercial scale in the same region. Cucumbers are extensively grown in the vicinity of Ripon, where a large pickling factory is located.

Trucking is carried on in the vicinity of Fond du Lac and the other important towns to supply the local markets, but no extensive areas are devoted to this type of farming. In the vicinity of Ripon and in a few other places considerable quantities of berries are grown with success.

While there are a number of small apple orchards in the area, the number of trees probably exceeding 60,000, this region is not considered to be within the portion of the State suited to the growing of apples on a commercial scale. This fact, however, should not prevent the planting of small orchards to supply the home with fruit.

Dairying is the most important type of farming followed in the county, and the one from which the largest income is derived by the farmers. The output is disposed of chiefly through creameries and cheese factories. There are 30 creameries and 59 cheese factories in the county and more than 42,000 dairy cows. Among these are some of the most valuable cows in the country. There are a number of herds of pure-bred Holsteins, Guernseys, and Jerseys. The grade animals which form the majority of the herds throughout the county are gradually being improved by the use of pure-bred sires.

The growing of beef cattle and the feeding of beeves for the market is not carried on in an extensive way, and but few farmers make a specialty of raising this type of cattle. While many farmers feed some steers each winter, they are mostly of dairy breeds or their grades. The fat stock shipped out of the county goes to the Chicago market.

Hog raising is an important branch of farming in the area, and as carried on in conjunction with dairying it is very profitable. On the average about 25 hogs are turned off each year from 100 acres. The leading breeds are Poland China and Berkshire. Some Chester Whites and Duroc-Jerseys are also raised.

There are about 34,000 sheep in the county, and it is estimated that one farmer out of five raises sheep. The eastern and southeastern parts of the area are better adapted to this pursuit than the western part.

The benefits to be derived from a systematic rotation of crops are generally understood. In almost all parts of the county a definite rotation is practiced by the leading farmers, though not in every case the one best adapted to the conditions under which it is being used. Methods and rotations vary somewhat in different parts of the survey, but the rotation most commonly followed consists of corn one year, barley one year, followed by oats one year (these may be changed in order), with clover and timothy seeded in the last grain crop. The field is cut for hay one or two years and may be pastured one year, after which it is manured and plowed again for corn. In the southeastern part of the county the land is so broken and many of the fields are so irregular in shape and variable in soil texture and adaptability that it is often very difficult to follow a definite system suited to all the conditions. The crop yields of most of the cash renters and the poorer farmers, where inferior methods are followed, are considerably lower than the yields obtained by the better farmers.

The Carrington silt loam, the Poygan clay, and the Clyde silty clay loam, where well drained, are better adapted to corn than the light-colored soils of the county. Small grains do best on the Miami silt loam. The grain is better in quality than on the black soils and there is not so much danger of lodging.

The methods of cultivation practiced are fairly well adapted to the conditions prevailing throughout the county at the present time. The large number of comfortable farmhouses, the large, well-painted barns, well-tilled fields, fine stock, and the generally neat appearance of the farms all indicate a condition of thrift and prosperity.

The problem of labor is frequently a serious one and often influences agriculture to the extent of making the system of farming followed conform to the supply of labor. In several instances it is reported that farms have been sold because competent labor could not be secured. It seems especially difficult to get hired help that will take a sufficient interest in the care which must be given dairy cows. Many object to milking. Students from the agricultural college are sometimes secured for the summer months to work on the leading dairy farms. Farm hands usually receive \$30 to \$35 a month, with board, or about \$400 per year, with a house and garden. Through haying and harvest time they are paid \$2 a day.

Of the land in the area, 95.8 per cent is in farms, of which 72.5 per cent is classed as improved. The average size of farms is 105 acres. Of the farms in the county, 80.2 per cent are operated by the owners. Where land is rented the share system is the most common, though in some cases a cash rent is paid. Under the share system the tenant usually furnishes labor and work animals, one-half of the other stock and seed, and returns the owner one-half of the crops. Cash rents range from \$3 to \$6 an acre.

The agriculture of Fond du Lac County as a whole is highly developed and considerably above the average for the State. There are, nevertheless, some changes which would tend to increase the productiveness of the soil, add to the income of the farmers, and still further develop the area. Practically all of the light-colored soils of the county are deficient in organic matter, and the amount of stable manure produced is seldom sufficient to supply the amount of humus-forming material needed. To supplement this, green manuring crops should be grown more extensively than is the practice at present. A legume is best for this purpose.

An acid condition exists on many of the soils and before the maximum yields can be obtained this condition must be corrected. The acidity is much more pronounced in some sections than in others. Applications of 2,000 pounds of ground limestone per acre will be sufficient to neutralize the acids and keep the soil sweet for a number of years. The application of rock phosphate to some of the soils, especially the Carrington silt loam, will undoubtedly increase the yields.

Alfalfa should be grown more generally. Every dairymen, at least, should grow this crop. When the soils are properly drained, limed, manured, and inoculated alfalfa can be successfully produced

on all of the heavier types in the county. In many places inoculation will not be necessary, since sweet clover is found growing wild in various parts of the county, and where this plant occurs the soils are already supplied with the proper bacteria. Not more than an acre or two should be planted at first, the area being extended as the methods of handling are learned.

The cultivation of special crops, such as sugar beets, peas for canning, cabbage, cucumbers for pickling, small fruits, and the like, could be increased in various parts of the county to advantage.

The question of drainage is one which should be given careful consideration in Fond du Lac County. In the low-lying section south and west of Fond du Lac there are thousands of acres which are producing fair crops each year, but which by the installation of tile drains could be made very much more productive. A large number of places in the Carrington silt loam could be improved by tiling and all the Clyde silty clay loam is deficiently drained. Up to the present time but little tiling has been done in the county, but there is no question that it would be profitable. Land values are high and it is poor economy to have a part of a high-priced farm on a nonproducing basis. Besides the poorly drained soil mentioned there are a large number of marshes within Fond du Lac County, the drainage of which constitutes a large problem. Such marshes, when properly drained, can be made to yield profitable crops, and their reclamation should be encouraged.

SOILS.

The Late Wisconsin Drift of the Pleistocene Period is the surface geological formation covering more than 95 per cent of the county. There are no soils in the county derived from the residual decay of the rocks, but the material from the underlying limestone has entered largely into the formation of the glacial débris covering. In the western half of the county the surface material appears to have some of the characteristics of loess and may have been deposited by wind action.

Outcrops of Potsdam sandstone, Lower Magnesian limestone, and St. Peters sandstone are found in the vicinity of Ripon, but contribute only very slightly to the material from which the soils of this neighborhood are derived. To the south and east of Ripon occur outcrops of Trenton limestone. The eroded remnants of the more indurated portion of this formation give rise to the rounded hills and knolls covered with irregular limestone fragments so conspicuous in this section of the county.

Bordering the Trenton limestone on the east and south is the Galena limestone, which outcrops prominently south of Rosendale and around Waupun, where it is quarried for road material. It is

also found as rounded knolls covered only with a thin mantle of soil. Overlying the Galena limestone is the Cincinnati shale, which is exposed slightly just below the escarpment mentioned in the description of the topography of the county. Overlying this is the Niagara limestone found in the cliffs along the east shore of Lake Winnebago and extending to the south and southwest as a series of rock outcrops forming a ledge varying in height from 50 to 150 feet.

The soils of the area are all derived from glacial or lacustrine material and owe their differences chiefly to the methods of deposition and to the character of the morainic topography in which they are found. Since first deposited numerous changes, due to water action, weathering, and accumulation of organic matter, have taken place.

The surface materials of variable characteristics have been classified into 8 soil series and 17 types, each of which has peculiarities readily distinguishing them.

The Miami series, which is by far the most extensive series in the county, comprises the light-colored glacial soils occupying the undulating to slightly rolling ground moraine throughout most of the county and the rougher Kettle moraine in the southeastern part of the survey. All the members of this series were originally timbered. The soil material contains considerable finely ground limestone, and in places coarser limestone fragments. Three types, the Miami silt loam, gravelly loam, and sandy loam, were recognized and mapped as belonging to this series.

The Fox soils are formed of light-colored glacial material occupying overwash plains or old, filled-in valleys, in which the material has been modified more or less by water action. But one type, the Fox silt loam, is mapped.

The Superior series is made up of soils that are composed largely of red clay, carrying only a comparatively small amount of organic matter at the surface. The topography is very smooth, so much so that the natural surface drainage is poor. The series occurs chiefly in the basin surrounding Lake Winnebago. Two types of this series, the silty clay loam, till phase, and the gravelly loam, are developed in the county.

The Kewaunee series is made up of soils that are red in color in both soil and subsoil, except where the soil may be bleached at the surface. The topography is rolling and the natural drainage is good. Most of the types are more or less stony or gravelly. The finer material of the soil is usually clay. One type, the clay loam, has been mapped in this county.

The Poygan series represents a lacustrine deposit similar to the Superior, but with which a considerable amount of organic matter has become incorporated through the decay of vegetation under moist conditions. This has resulted in a black surface soil, beneath which

the red clay of the Superior is found. It is closely associated with the Superior series, but occupies a slightly lower level. Two types, the Poygan clay and the fine sandy loam, were mapped as belonging to this series.

The Carrington series comprises the dark-colored prairie soils derived from glacial till. It is confined to the western part of the county. Two types, the Carrington silt loam and the gravelly loam, were mapped.

The Clyde series occupies old lake beds, ponded valleys, and the valleys of present-day streams where there has been an accumulation of organic matter in quantities not sufficient to form Muck or Peat. Three types, the Clyde silty clay loam, silt loam, and fine sand, were recognized.

Another group of soils has been given the name Rodman. The surface material of this series varies in color from different shades of light brown to yellow. They are frequently made gray by the presence of organic matter, and in some cases have a slight reddish cast. The material is found as eskers and kames, and has therefore been formed within or underneath the glacial ice. While this material has been assorted, stratification or cross bedding is in many places indefinite. The soils of this series, though in some cases they may have been covered by waters of glacial lakes, have not been modified by the action of such water to a great extent. This distinguishes the types from the soils of the Dunkirk or other series formed from the glacial lake sediments. Two types of this series were mapped, the gravelly sand and the gravel.

Peat, with included areas of Muck, occupies old lake beds, ponded valleys, etc., where there has been a great accumulation of vegetable matter in various stages of decomposition, but with which there is only a comparatively small amount of mineral matter.

The following table gives the actual and relative extent of the several soils mapped in the survey of Fond du Lac County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam.....	96,000		Rodman gravel.....	4,480	1.0
Deep phase.....	82,752	38.0	Clyde silt loam.....	3,008	.6
Peat (with included areas of Muck). .	62,720	13.3	Carrington gravelly loam.....	1,920	.4
Clyde silty clay loam.....	51,968	11.1	Superior gravelly loam.....	1,280	.3
Carrington silt loam.....	46,592	9.9	Miami sandy loam.....	1,280	.3
Miami gravelly loam.....	45,184	9.6	Clyde fine sand.....	896	.2
Poygan clay.....	28,096	6.0	Rodman gravelly sand.....	640	.1
Kewaunee clay loam.....	25,728	5.5	Poygan fine sandy loam.....	320	.1
Fox silt loam.....	8,832	1.9	Total.....	469,760	-----
Superior silty clay loam, till phase.....	8,064	1.7			

MIAMI SILT LOAM.

The surface soil of the Miami silt loam consists of a friable silt loam extending to an average depth of 10 inches. The silt content is high and the soil has a smooth feel. When moist the color is a grayish brown, but when dry it frequently has an ashy appearance. The light color of the type is indicative of a low organic-matter content.

The subsoil consists of a light-yellow silty clay loam, in which the clay content increases with depth until a yellowish-brown heavy clay loam or chocolate-brown clay loam is encountered at a depth of 20 to 26 inches. This material frequently extends to more than 3 feet, though at depths ranging from 2 to 4 feet a gritty clay loam or gravelly material is usually encountered. This mixture of clay, sand, gravel, and boulders is true glacial till, and extends to a depth of 10 to 25 feet.

Where the topography is level or only gently rolling, the gritty material lies at a greater depth than is the case on the slopes of hills and ridges. In the latter the silty covering has been partly removed by erosion and the silty clay loam exposed over areas of limited extent. Underlying this mantle the gravelly material and occasional beds of sand are found within reach of the 3-foot auger. This is especially true in the southeastern part of the county, where the soil and subsoil sometimes contain small quantities of fine sand, with some gravel on the surface. Boulders and pockets of gravel occur in some sections and in places the stones are so numerous that the fences have been made of them. Wherever the bedrock comes close to the surface the subsoil directly over the rock is heavier than where it is underlain by the gravelly material.

The Miami silt loam, including the deep phase, is the most extensive and important type in Fond du Lac County. The typical soil predominates in the eastern part and is associated with several other types of the same series. The limestone ledge or escarpment running through the county and the extensive body of Poygan and Superior soils occupying the flat country south and west from Fond du Lac separate the areas of the typical soil from that of the deep phase. This division is an arbitrary one, however, as both the typical soil and the phase may be found on either side of the ledge.

The type occupies the tops and lower slopes of drumlins, kames, and glacial ridges, the more gently rolling land intervening, and in a few places areas of level land. Where the slopes are steep some erosion takes place, but no large areas have been damaged in this way. The natural drainage is good over most of the type, but on the level to undulating areas tile drains could be used to advantage in many places.

The material composing this type is derived from the weathering of glacial drift that occurs chiefly as ground moraine. Limestone constitutes the predominating stony material throughout all the soil, but in spite of this fact much of the lime has been removed from the surface by leaching and a slightly acid condition is found to exist in places, as indicated by the litmus test.

The timber growth on this type was rather heavy, consisting of several varieties of oak, ash, hickory, basswood, maple, wild cherry, and elm. At present practically all of the merchantable timber has been removed, only small woodlots remaining. The largest forested areas are found on the roughest lands.

A very large proportion of the Miami silt loam is improved and highly developed. All of the general farm crops common to this region and some special crops are grown. The type of farming followed consists of dairying in conjunction with general farming. In the eastern part corn ranges from 30 to 55 bushels, with an average of 45 bushels, oats from 35 to 50 bushels, and wheat from 15 to 25 bushels per acre. Timothy and clover are grown more extensively for hay than other legumes or grasses and produce hay of excellent quality. Some trouble is reported in getting a good stand of clover because of winter-killing, and many farmers consequently use timothy alone.

Alfalfa is being grown by a number of farmers and is coming to be an important crop, though the acreage is not equal to that of clover. Sweet clover grows in many parts of the county and in such places it is probable that no inoculation would be necessary. The soil seems fairly well adapted to alfalfa and the acreage is gradually increasing.

In the cultivation of this type fall plowing is quite common, though because of its friable structure the soil can be worked early in the spring. The subsoil is retentive of moisture and the ease with which a good surface mulch is obtained makes it well suited to resist drought. Barnyard manure is the only fertilizer used extensively, and as dairying is extensively practiced a good supply is always available. From 10 to 15 loads per acre is usually applied every four or five years. It is customary to apply it on sod land to be plowed for corn. Green manuring crops are used to a small extent, though the practice is not common.

Plowing and subsequent cultivation, such as harrowing and disk-ing, are not difficult, since the soil is very silty and pulverizes more readily than a clay. Where the subsoil is exposed on slopes or where the surface covering is shallow and the heavier material is turned up by the plow, some difficulty is experienced in cultivation.

The rotation of crops most commonly followed consists of corn one year, barley and oats one year each, followed by timothy and

clover mixed. Where wheat is grown it may take the place of either oats or barley or it may be made another step in the rotation. The grass is usually left for two years, being cut for hay the first year, sometimes for two years, and pastured one year. Where there is considerable permanent pasture land such as is provided by Marsh and the Clyde silty clay loam, the upland soil is used very little for pasture.

Among the special crops grown on this type sugar beets may be mentioned as receiving considerable attention, especially in the vicinity of Campbellsport. Yields range from 12 to 15 tons per acre and the sugar content is high. Because of the silty nature of the soil and its friable condition it is comparatively easy to maintain a good surface mulch and the work of cultivating the crop is less arduous than on the heavier types.

Irish potatoes are not grown extensively, although most farmers produce enough for home use and frequently have some to sell. The yield ranges from 150 to 200 bushels per acre and the quality is good.

The most important factor to be considered in the cultivation of the Miami silt loam is increasing the content of organic matter. Liberal applications of manure are the best means of supplying organic matter, but as the supply of stable manure is in most cases inadequate to meet the needs of the entire farm, green manuring crops should be grown and plowed under. Legumes are more valuable for this purpose than other crops.

The importance of following a carefully worked-out crop rotation is clearly demonstrated by the heavy yields many farmers are obtaining when special attention is given to this matter.

The acid condition of the soil found in places can be readily corrected by the application of ground limestone or burnt lime. This tends to increase the yields by making the conditions more favorable for plant growth.

Dairying could be carried to a still higher stage of development on this soil. Alfalfa should be grown more extensively and every dairy farmer should include this legume in his list of farm crops. The raising of hogs could also be profitably extended.

The selling price of farms of the Miami silt loam ranges from \$50 to \$150 an acre, depending upon location, topography, improvements, and the condition of the soil. The average price is about \$95 an acre.

Miami silt loam, deep phase.—The soil of the deep phase of the Miami silt loam consists of a grayish-brown silt loam extending to an average depth of 10 inches and having a very smooth feel. It is underlain by a yellow or yellowish-brown silt loam which grades through a heavy silt loam into a silty clay loam, the clay content gradually increasing with depth. This phase of the type is very uniform, especially in the surface 2 feet. In cuts a very distinct line is

noticed between the surface material, which is decidedly silty, smooth, and free from gravel and bowlders, and the underlying true glacial till, which consists of a mixture of clay, silt, sand, gravel, and stones. Bowlders are very rarely found upon the surface, and gravel and sand are absent except on slopes or the tops of ridges where the surface has been eroded and the underlying till partially exposed. As in the eastern part of the county, the underlying rock may come within 2 feet of the surface in places and occasionally within plow depth.

The deep subsoil and substratum of this phase of the Miami silt loam is typical glacial till. The material seems to be of limestone derivation largely, the stony material being mainly limestone. This, however, is covered by a layer of silty material with many of the characteristics of loess. It differs, however, from a typical loess stratum in its rather heavy subsoil. Its origin has not been definitely determined.

Where the phase borders the Carrington silt loam the soil and subsoil are of a darker color than the typical. This border phase is considered the best soil in the county. Adjacent to the Clyde silty clay loam the surface is also darker, except in a few instances, where a light ashy gray surface soil is found. This is apparently the Clyde silty clay loam, from which a covering of peat has been burned off. This phase is confined chiefly to the western portion of the county, although there are some small areas east of the ledge which could be classed with this phase.

When the white man first settled this county this soil supported an open forest which was called "openings," while the typical soil supported a much denser growth of trees.

Topographically this area is smoother than the main portion of the type. The local relief reaches a maximum of less than 100 feet and the slopes are universally gentle. As a whole it is gently undulating.

This phase, as a whole, is more productive than the typical soil. The yield of corn varies from 30 to 70 bushels per acre, barley from 25 to 45 bushels, oats from 35 to 70 bushels, wheat from 15 to 30 bushels, and potatoes from 150 to 200 bushels. Alfalfa yields from $2\frac{1}{2}$ to 4 tons per acre and clover and timothy from 1 to $2\frac{1}{2}$ tons.

The type of farming is essentially the same as that on the typical soil, except that on account of the smoother topography and the somewhat higher fertility the growing of grain for market is practiced more than on the main type. While the sugar beet is a special crop on the type, it is not grown to any extent on the deep phase; the growing of peas, however, for canning receives some attention.

The color of the phase varies greatly with moisture conditions, becoming darker as the moisture content increases. The amount of vegetable matter also has its effect on the color.

The following table gives the average results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Miami silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
311031, 311037.....	Soil.....	0.2	0.7	0.7	2.2	12.1	68.1	15.8
311032, 311038.....	Subsoil.....	.2	.5	.9	2.8	9.9	54.3	31.1

MIAMI GRAVELLY LOAM.

The Miami gravelly loam consists of a light-brown to yellowish-brown silt loam extending to an average depth of 8 inches, and underlain by a brown to yellowish-brown silty clay loam or slightly reddish brown, stiff sandy gravelly clay. This in turn is underlain by a heterogeneous mixture of sand, gravel, clay, and boulders, varying in thickness from 2 or 3 feet to over 25 feet in places. Gravel and boulders in varying quantities are frequently found upon the surface and mixed with the soil.

The Miami gravelly loam in Fond du Lac County may be divided into three phases which are distinct, although not of sufficient importance in themselves to be classified separately. The first is found on hills more or less regular in shape and varying in height from 25 to 150 feet. The soil on the steeper slopes is frequently thin, the gravel often coming to within 12 inches of the surface. The silty covering has in some places been removed by erosion. On the tops of these hills there is a greater depth of soil, and in places it is sufficiently deep to be classed as Miami silt loam. Where gravel was not found nearer the surface than 22 to 28 inches and the area was large enough to be mapped the material was classed with the Miami silt loam.

The second phase consists of areas where the topography is bumpy and ridgy. In such locations the gravel at times approaches within a few inches of the surface, while in the intervening depressions the surface soil extends to a considerable depth. Where these knolls are found close together the whole region has been mapped as gravelly loam. Where the gravel ridge in itself was of sufficient extent to map it has been classed as Rodman gravel, while the low-lying areas where the soil was found to be deep were mapped as Miami silt loam. These two conditions are found most largely in the eastern and southeastern parts of the county.

The third phase is confined to the western part of the survey. The type occurs here on small knolls or hills having a rock core. The underlying limestone approaches the surface and outcrops frequently. The solid portion of the rock is often covered with a broken mass of irregular rock fragments. This material is usually

covered with 10 to 24 inches of good soil, though the soil section is itself sometimes filled with broken rock and the surface strewn with fragments varying in size from one-half inch to several inches in diameter. Angular boulders are also seen in many places on the type. Many of these knolls are very small, and where standing alone can not be indicated on the map; where several appear close together or where individuals are of sufficient size they are shown.

The Miami gravelly loam is most extensively developed in the eastern part of the county, but is found in all parts where the Miami silt loam has been mapped.

The topography varies considerably. In some places it is bumpy and broken, although over most of the area it is rolling. On the large hills in the eastern part of the county the slopes are sometimes steep and broken. In these places the prevention of erosion is a serious problem, and in many places where the land has been left uncovered for a season large gullies have been formed. It is only with difficulty that such erosion can be checked when once started. Throughout all the type the natural drainage is good and in some places it is excessive, causing the soil to be droughty in years of low rainfall.

The Miami gravelly loam has been derived from the glacial till which covers most of the region. It occurs in the form of drumlins, kames, eskers, and moraines. In the western part of the county the underlying rock has contributed to the type by supplying the broken and weathered rock fragments found in the till. The gravel in the morainic material is 90 to 95 per cent limestone. Much of the gravel material has weathered to form the fine earth soil.

The original forest growth consisted chiefly of maple, oak, and some hickory. The growth was heavier than that found on the Miami silt loam in the eastern part of the county.

Where there is a covering of from 16 to 24 inches of soil over the underlying gravel and the topography is not too steep, good crops are grown on this type during seasons of average rainfall, but where the broken limestone comes within a foot of the surface and small outcrops occur, or where the covering of soil has been eroded away, the yields are low, as the type is droughty and difficult to handle. In such places it is of value for grazing rather than for cultivated crops. The soil along the lower slopes and in the depressions is as productive as the Miami silt loam.

Because of the variable character of the type it would be difficult to give yields which might serve as a fair basis for estimating the productivity of this type. In general it may be said that the yields are lower than those obtained on the Miami silt loam, although on the better portions of the type the yields frequently equal the average of the silt loam. The same general farm crops are grown as on the silt loam. About the same rotations are followed, and fertilization is confined to applications of barnyard manure. On the steeper cul-

tivated slopes it is advisable to follow a rotation in which no inter-tilled crops are used, since danger from erosion is less when the land is covered.

About half of the type is under cultivation. Where the steep surfaces are plowed it is necessary to take steps to check erosion by plowing across rather than up and down the slopes. Forests now standing should be allowed to remain.

Where the soil has a depth of 16 to 24 inches and the field can be properly cultivated, alfalfa will do very well, since the underlying gravel furnishes ideal drainage conditions. The surface soil is low in organic matter, however, and this should be increased by the application of stable manure and by plowing under green crops, preferably legumes. Since much of the land can best be used as pasture, and as alfalfa can be grown in many places, the dairy industry is probably better suited to this type than any other line of farming. The lower slopes and intervening depressions afford sufficient land for the growing of corn and the other necessary cultivated crops.

The value of the best land of this type, where favorably located, is about \$75 an acre. Where the soil covering is thin and the rock outcrops frequent, or where the gravel comes close to the surface, the value is considerably less, probably not over \$15 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil:

Mechanical analyses of Miami gravelly loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
311023.....	Soil.....	1.3	4.4	7.0	18.2	13.3	37.3	18.4
311024.....	Subsoil.....	1.9	5.5	6.5	22.6	22.2	26.7	14.2

MIAMI SANDY LOAM.

The surface soil of the Miami sandy loam consists of 10 inches of a yellowish-brown sandy loam of medium texture, rather loose structure, and having a relatively low content of organic matter. The subsoil consists of a medium-textured sandy loam of a lighter yellow color than the soil. With increased depth the clay content increases until, at 18 to 26 inches, it is a sandy clay, which, in many places, is sticky. This layer of heavy material varies in thickness from 6 or 8 inches to several feet.

The Miami sandy loam type is subject to some variation, especially in the subsoil. At a depth of 24 to 30 inches a yellow or whitish fine to medium sand may be found. This sand contains very little clay and sometimes extends below the reach of the auger, though another strata of clay may be found at 3 feet, just below

the stratum of sand. In the area in section 28, Auburn Township, there are a few small ridges, only a few feet in height, where there is considerable coarse material in the soil and subsoil and only a small quantity of clay in the subsoil. None of the variations are of sufficient importance to be mapped separately.

The type is not extensive, there being only about 3 square miles in the county. A small area is found northwest of Ripon, the remainder being confined to the southeastern part of the county in the townships of Osceola, Auburn, and Ashford.

The topography is undulating to gently rolling. Because of its sandy nature and the topography, the natural drainage is good, and there is never too much moisture in the soil. During dry seasons the type suffers somewhat from drought.

The Miami sandy loam is derived from the weathering of glacial débris, which covers practically the entire county. The original forest growth consisted of bur oak and white oak, with scattered maple, basswood, and birch. Nearly all the timber has been removed.

All the general farm crops common to this region are produced from this type. Rye is grown to some extent. Corn yields from 30 to 35 bushels per acre, oats 25 to 30 bushels; barley is grown with fair yields, but does better on the heavier soils. Timothy and clover are grown for hay, yielding from 1 ton to 1½ tons per acre. Rye yields about 15 bushels per acre. Potatoes are especially well adapted to this type, being of good quality and yielding from 125 to 175 bushels per acre. Although alfalfa has been grown only in a few instances it has been found to do well. A slightly acid condition noted in the soil should be corrected.

The rotation of crops most commonly followed includes potatoes as well as corn, grain, and grass. Most farmers try to seed the land to grass every four or five years. Stable manure is applied to the sod at the rate of 10 to 12 loads per acre, although this amount is insufficient to supply the needs of the soil. A number of farmers sow rye for late fall pasture and plow it under in the spring as a green manure. Some legume crop would be better for this purpose.

The price of land of this character ranges from \$75 to \$100 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Miami sandy loam:

Mechanical analyses of Miami sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
311043.....	Soil.....	0.3	3.3	29.7	41.2	2.0	16.8	6.6
311044.....	Subsoil.....	.2	2.5	28.4	40.9	2.5	14.8	10.8

RODMAN GRAVELLY SAND.

The surface soil of the Rodman gravelly sand consists of a yellowish-brown, loose, fine sand having an average depth of 6 inches. Considerable gravel is found upon the surface and mixed with the soil. The subsoil consists of a yellow fine sand, containing only a small percentage of silt and clay. The material frequently becomes coarser at 3 feet. In places the sand extends to a depth of 30 feet or more, and at irregular intervals layers of gravel are found.

A small area of this type is found. It is confined to the townships of Auburn, Osceola, and Ashford, where it occurs in a few scattered bodies. It is nearly always associated with the Miami sandy loam, and occupies knolls and ridges from 20 to 40 feet higher than the latter type. The soil resembles the Rodman gravel, but the content of the latter material is considerably smaller, and there is but little clay or other fine material present. Because of its loose, open structure and its topography the drainage is excessive and the type droughty.

The Rodman gravelly sand is of glacial origin and consists of morainic material in which the sand and gravel have been separated from the finer particles and deposited by the receding ice sheet.

This is one of the poorest types in the county, and very little of it is under cultivation. During the spring and early summer some pasturage is afforded, but the grass dies down during the summer for lack of moisture. When the virgin soil is first cultivated there is some organic matter present, but after a few years it disappears and the surface has the appearance of a bare sand dune sprinkled with gravel. The land is usually abandoned after a few years' cultivation. Maximum yields on newly cleared areas are: Corn from 15 to 25 bushels; rye, 12 bushels; oats, 18 to 20 bushels; buckwheat, 12 to 15 bushels; and potatoes from 50 to 60 bushels per acre. The potatoes grown are of excellent quality.

Because of the droughty condition, loose, open structure, low organic-matter content, and consequent poor yields obtained, this type has a very low value.

RODMAN GRAVEL.

The surface soil of the Rodman gravel consists of a yellowish-brown to dark-brown fine sandy loam, carrying a considerable quantity of gravel and extending to an average depth of 8 inches. The subsoil consists of a mass of sand, gravel, cobbles, and boulders. Seams of sand several feet in thickness may occur in which there are no stones, while again there may be but little sand with the gravel. Stones and boulders occur upon the surface and the structure of both soil and subsoil is loose and open.

This type of soil is found chiefly in the eastern and southeastern parts of the county, though a few small areas occur in the western townships. It occupies narrow ridges, eskers, and kames, and where these are clustered together the topography is hummocky. It is most extensively associated with the Kettle moraine. The material forming the type is of glacial origin.

The Rodman gravel is one of the poorest types mapped and may be considered nonagricultural. It is generally forested with a scrubby growth of oak and is used for pasture. During spring and early summer it supports a fair growth of grass, but later this dries up, unless the rainfall is heavy, as the soil is very droughty. A few small areas have been plowed and sowed to rye for pasture. Sheep raising is carried on to some extent where this type is found.

The gravel is used extensively for road building, and the sand and gravel make good concrete material. The boulders provide material for building foundations.

FOX SILT LOAM.

The surface soil of the Fox silt loam consists of an extremely smooth, ashy-gray silt loam, of floury feel, extending to an average depth of 12 inches. Below the surface 3 or 4 inches the soil is slightly lighter in color, but the texture continues uniform. No coarse particles are found in the surface soil.

The subsoil to a depth of 24 to 34 inches grades from a light yellowish brown silt loam through a silty clay loam into a chocolate-brown, compact clay loam, becoming somewhat gritty in the lower portion. Beneath this occurs a bed of stratified gravel from 10 to 12 feet thick, in which there is but little sand or finer particles. In some places the gravel may come to within a foot of the surface, but usually it lies from 20 to 24 inches below the surface.

The type is found in the eastern part of the county, chiefly in Ashford, Osceola, Eden, Forest, and Marshfield Townships, in areas of small extent. The largest single area is in Marshfield Township, and extends over a broad, level plain, surrounded by rolling areas of Miami gravelly loam and Rodman gravel.

The surface of the type is undulating to level. Because of the underlying bed of gravel, the drainage is good and the excess water from heavy rains soon escapes. On the other hand, the soil is sufficiently heavy to retain moisture for growing crops, and the type does not suffer from drought except in places where the gravel comes close to the surface or during long-continued dry spells.

The soil, though of glacial origin, has been modified greatly by water action. The gravel and sandy material were deposited as over-wash plains by streams issuing from beneath the ice sheet. The silty covering may have been deposited later in the quiet waters of

glacial lakes, or where the surface is undulating it may have been laid down by the wind. The gravelly and sandy material is stratified, but no stratification was observed in the silty covering.

This type resembles the Miami silt loam in the texture and color of the surface soil, but differs from it in having a continuous underlying gravel bed and also in topography. This is considered a good general farming soil and all the ordinary farm crops of the region are grown upon it. Corn yields from 40 to 50 bushels, oats 25 to 40 bushels, barley 20 to 30 bushels, wheat 20 to 30 bushels, and hay from $1\frac{1}{2}$ to 2 tons per acre. The usual rotation consists of corn, barley or wheat, oats, and grass. Manure at the rate of 10 to 12 loads per acre is usually applied to sod land before plowing for corn. Dairying is the most common type of farming, and the industry is fairly well developed.

As the type is low in organic matter, stable manure and green manuring crops should be used liberally. Legumes will give the best results when plowed under. The growing of alfalfa should be extended. The excellent drainage resulting from the gravelly subsoil makes the type well adapted to this crop. Where an acid condition exists, this should be corrected by applying ground limestone or burnt lime.

Land of this type of soil sells for \$80 to \$125 an acre.

KEWAUNEE CLAY LOAM.

The surface soil of the Kewaunee clay loam, to an average depth of 8 inches, consists of a brown to reddish-brown clay loam, which contains a considerable amount of silt. The silt content, however, is not sufficient to make the type a silty clay loam. The surface material is usually quite compact, and it often follows that the deeper the color, the more compact the soil. The subsoil consists of a heavy, plastic light-red clay, which extends to a depth which is undetermined, but which is known to be considerably more than 3 feet. When wet, the subsoil is sticky and when dry it checks and cracks into small cubes. Limestone fragments are found in both soil and subsoil, but are more numerous in the subsoil. They occur more extensively in the type east of Lake Winnebago than elsewhere.

A variation from the typical soil was seen in a few small areas, where the surface soil consists of from 4 to 8 inches of a yellowish-gray silt loam, very smooth and free from all coarse particles, resting upon the typical red-clay subsoil. In the virgin soil of these areas the surface is very silty, having the smooth feel characteristic of a silt loam. When this is plowed, however, some of the underlying clay becomes mixed with the surface soil, which tends to make the cultivated fields heavier at the surface than the virgin areas. In a

few places the silty covering was found to extend to a depth of 10 to 12 inches.

The Kewaunee clay loam is confined to the central and north-central portions of the county to the east, west, and south of Lake Winnebago and its extreme limits are, in a general way, nearly parallel with the shore of the lake.

The topography of that part of the type occurring south and west of Lake Winnebago is that of a low ridge lying from 10 to 40 feet above the adjacent lowlands, the top having an undulating surface and the side slopes being rather gentle. The latter, however, are steep enough in places to be affected by erosion, so that the lighter-colored surface material is eroded, exposing the underlying heavier, redder clay. This is the case also in places on the top of ridges. East of Lake Winnebago the topography of the type is considerably rougher than west of it. It lies along the frontal slope of the escarpment formed by the Niagara limestone, the Kewaunee soils occurring only where the rock is covered by the coating of red clay. In the northern part of the county the escarpment is much less steep than farther south, so that the topography is smoother.

The surface drainage is generally adequate, though the material is compact and water moves through the subsoil slowly. Even where the surface is sufficiently rolling to drain all the surface water, tile drains would in many places improve the soil. Where the surface of the material is level so as to be naturally poorly drained and of a different agricultural value, such material has been classed as a separate type.

The Kewaunee clay loam has been derived from ice-laid material consisting in this area mainly of red clay with varying proportions of coarser material, a considerable part of which is limestone.

The original timber growth consisted of oak, ash, elm, ironwood, maple, and hickory. Only a very small amount of timber is now standing.

The Kewaunee clay loam is an important soil and one of the highly improved types of Fond du Lac County. It is not as extensive as the Miami silt loam or the Carrington silt loam, but most of it is as highly developed agriculturally. The soil is well adapted to general farming and dairying, which is the prevailing type of agriculture at present. All of the crops common to this region are successfully grown. The type is especially well adapted to grasses and small grains, but not so well adapted to corn, though good crops are obtained. Corn yields from 35 to 50 bushels and oats from 40 to 50 bushels per acre. Yields of 30 to 50 bushels of barley have been reported. The acreage devoted to this crop appears to be decreasing. Continued cropping has reduced the yield so that the average at present is about 20 to 25 bushels per acre. Wheat was one of the

leading crops, but little is grown at present. Yields of 25 to 30 bushels were formerly secured, though these figures are rarely reached at the present time. Timothy and clover do very well, yielding from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons per acre of first-quality hay. Alfalfa is being grown by quite a number of farmers, especially east of Lake Winnebago, and good success has been met with. Yields of 4 tons per acre are not uncommon, though about 3 tons is the average. Three cuttings are usually made, though four have been obtained, and yields as high as 6 tons per acre reported. This yield, however, is unusual.

Fall plowing is quite generally practiced and it is almost a necessity if good tilth is to be obtained with the minimum amount of labor. The type is apt to be wet in the spring and if plowed in this condition is cloddy, making subsequent cultural operations difficult. When the soil becomes puddled, as sometimes happens, it usually takes several years to get the land back into first-class tilth. The heavy rollers sometimes used to break up the lumps frequently pack the soil too much, and a crusher of plank or some such implement is found to be more effective. When the type is plowed in the fall and the spring cultivation not taken up until the moisture conditions are favorable, a good seed bed can usually be secured without much trouble, although this type is probably more difficult to handle than any of the other soils of the county.

A crop rotation in common use consists of corn, oats, barley or wheat, and hay. Hay is cut for one or two years, after which the field may be pastured for one year. Manure is usually applied to sod land to be plowed for corn.

The Kewaunee clay loam is somewhat deficient in organic matter. To overcome this defect a crop of some kind, preferably a legume, should be plowed under every few years to supplement the stable manure, of which there is seldom enough. Cultural methods should be given careful attention and if shallow plowing has been the rule the depth should be gradually increased from year to year until 10 to 12 inches of the soil is broken. The addition of organic matter will tend to loosen the soil and make cultivation less difficult.

Farms on this type range in value from \$75 to \$150 an acre, depending upon location, improvements, and the condition of the soil.

SUPERIOR SILTY CLAY LOAM, TILL PHASE.

The surface soil of this type consists of a brown to reddish-brown clay loam extending to an average depth of about 8 inches. It is very similar in texture to the Kewaunee clay loam, perhaps containing a little more silt, and as a whole the surface soil is slightly deeper. The subsoil is a heavy, plastic red clay, extending to a depth of much more than 3 feet. When wet, the material becomes very sticky and

on drying checks and cracks into small cubes. On account of being poorly drained the physical condition is somewhat inferior to that of the Kewaunee clay loam, since it is more often worked under unfavorable moisture conditions. Small limestone fragments occur in both soil and subsoil and small rounded gravel and a few stones are frequently seen.

The Superior silty clay loam, till phase, is confined to the lowland adjacent to Lake Winnebago and the largest areas occur immediately west of the lake, extending southward for a few miles to the south and west of Fond du Lac. It is closely associated with the Poygan clay, but occupies a slightly higher elevation, though the difference is often not more than a few feet.

In topography the surface is level or only very slightly undulating and the natural surface and underdrainage is poor. This is the chief point of difference between the type and the Kewaunee clay loam, where the surface is always sufficiently uneven to insure adequate surface drainage. Open ditches have been constructed but only a few tiles have been used.

In origin this type has been derived from both lake-laid and ice-laid material. Its fundamental series characteristic is its poor surface drainage, due to its smooth topography. This is increased in its effect in the heavier types by its naturally poor underdrainage.

The original timber growth was the same as on the Kewaunee clay loam, though it was not as dense. Practically all of the timber has been removed and the land improved.

All of the type is now in farms, though portions of it are too wet most of the year for cultivated crops, and such fields are kept in grass for hay and pasture. The same crops are grown as on the Kewaunee clay loam, though the yields will probably average a little lower. Alfalfa is not grown as extensively, however, on account of the poor drainage conditions. In wet years yields are usually lower than on the Kewaunee clay loam, but during dry seasons they are about equal. The methods of farming are essentially the same on both types.

In the higher improvement of this type the most important factor is to establish thorough drainage. This can best be done by installing numerous tile drains. Other methods of improvement suggested for the Kewaunee clay loam will all apply to this phase.

The agricultural value of the type is as a whole somewhat inferior to that of the Kewaunee clay loam, but on account of its being located nearer Fond du Lac the selling price is equal to that of the better-drained land.

Mechanical analyses of Superior silty clay loam, till phase.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
311005.....	Soil.....	0.6	3.5	4.3	9.8	8.2	48.3	25.3
311006.....	Subsoil.....	1.3	1.6	2.0	6.4	9.7	28.7	50.5

SUPERIOR GRAVELLY LOAM.¹

The Superior gravelly loam consists of a brown or reddish-brown heavy sandy loam to clay loam averaging 19 inches in depth and containing small amounts of medium to coarse gravel. This is undelain by a gravel bed varying in thickness from 18 inches to several feet, which in turn rests upon the red Superior clay material. The gravel bed contains stratified sand and gravel, the latter ranging in size from small pebbles to cobbles of different sizes.

Where associated with the Poygan clay the soil is much darker in color, but such areas, because of their small extent, could not be mapped separately.

The type is found in long, narrow, broken ridges from 10 to 30 acres in extent, running parallel with and from one-half to 4 miles back from the shore of Lake Winnebago. The ridges lie from 1 to 10 feet above the surrounding country and occur near the 800-foot contour line, though some have been mapped at lower levels.

Because of the shallow soil covering and the sandy, gravelly nature of the subsoil, the natural drainage is sometimes excessive and the type is droughty in places.

The soil is of glacial-lacustrine origin. The gravel is beach gravel and represents the shore line of Green Bay and Lake Winnebago when the waters stood at higher levels than at present. A very definite shore line has been traced through Fond du Lac and adjoining counties at the 800-foot elevation.

The original timber growth was chiefly of oak, with a few other species of hardwood. About three-fourths of the type is still in forest, though the growth is somewhat scrubby.

About 25 per cent of the type is utilized for cultivated crops. Fair yields of corn, oats, barley, and wheat are obtained, but the type is droughty and crops suffer unless the rainfall is well distributed throughout the growing season. Crops do best where the gravelly loam occurs with the Poygan clay and where the soil has a larger content of organic matter present. Some alfalfa has been grown with success.

¹ In the future this type of soil will be mapped as Kewaunee gravelly loam, on account of its good surface and underdrainage.

The Superior gravelly loam is probably more valuable as a source of road material than as farming land. Numerous gravel pits have been opened in the ridges from which gravel of good quality is taken to crown the roads throughout the region of heavy clay soils.

POYGAN CLAY.

The surface soil of the Poygan clay consists of a dark-brown to black silty clay loam about 10 inches deep, rather sticky and plastic when wet, and inclined to check and crack when dry. The dark color is due to accumulations of organic matter, the content being much larger than in the Superior silty clay loam, till phase.

The subsoil consists of a stiff, tenacious red clay extending to a depth of 3 feet or more. The color grades from black to red, with a slightly bluish cast between soil and subsoil. Small lime concretions and particles of limestone are found scattered throughout the subsoil.

The type is fairly uniform, except along streams, where the surface is in some places slightly loamy, and in the northwestern part of Section 12, Lamartine Township, where the soil has a silty texture. The greatest variation occurs in the color of the subsoil. In low-lying, poorly drained areas the subsoil is frequently yellow, bluish, or drab, with occasional iron stains. Red clay is sometimes found beneath the drab material within reach of the auger. This pronounced coloring is due to advanced oxidation, which, in the case of the yellow and blue clays, has been retarded by poor drainage.

The type is found in the vicinity of Lake Winnebago, where it occupies the low-lying sections associated with the Superior silty clay loam, till phase, area. A large area extends south and west from the lake into Oakfield Township. The type is confined to an area that was probably an extension of the lake when the waters stood at a higher level.

The topography is level to undulating, and because of the even surface and the heavy character of the soil the natural drainage is poor.

The type is of the same origin as the Superior silty clay loam, till phase, having been deposited in interglacial times, when the waters of Green Bay and Lake Winnebago were more extensive. The material does not seem to have been influenced to as great an extent by glacial action as the Superior type. Owing to a low, poorly drained position, conditions have favored the accumulation of a large quantity of organic matter in the soil. Litmus tests occasionally show traces of acidity.

As is usual in low, wet lands, grasses form the most important vegetation, with few trees. The original tree growth consisted chiefly of willow and poplar in the wetter places, with elm, some oak, and hickory where the land was better drained. Some areas of the type are called prairie.

From 60 to 70 per cent of the type is under cultivation to the general farm crops, of which corn is the most important. The type is better adapted to its growth than the Superior silty clay loam, till phase, and yields of 40 to 60 bushels per acre are not uncommon. Oats yield from 40 to 50 bushels, barley 25 to 40 bushels, wheat 25 to 30 bushels, and hay from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons to the acre.

Sugar beets are grown as a special crop, yielding from 12 to 15 tons per acre. The lighter phases of the type are better adapted to this crop than the areas of heavy soil. In the vicinity of Fond du Lac some trucking is carried on to supply the city market. Alfalfa is grown to a limited extent. On the best drained areas it does well and yields from 3 to 4 tons per acre.

As is the case with the Superior silty clay loam, till phase, fall plowing is extensively practiced, for in the spring the land is likely to be wet and not in condition to work until late. When plowed in the fall and not cultivated in the spring until the moisture conditions are the most favorable, but little difficulty is experienced in obtaining a good seed bed. If plowed when wet, especially in the spring, the soil clods and is hard to handle.

Dairying has developed into an important industry on this type, and there is consequently a large amount of manure available. The manure is used on fields which have been standing in pasture for a number of years before breaking the land for corn. A small grain crop follows for three years, and then the field is put back into corn. Most of the crops are fed on the farm, barley being the only cash crop. Even under this arrangement the importance of including a legume in the rotation should not be overlooked.

Drainage is the most important factor to be considered in the management of this type. Fields are frequently plowed in narrow lands, allowing the dead furrow to act as a shallow ditch which conducts the water to other open ditches along their sides. In most cases this system is inadequate, as heavy clay subsoil makes the internal drainage sluggish. Tile drains should be installed wherever practicable.

Land of this type ranges in value from \$40 to \$125 an acre, depending upon drainage conditions, location, and improvements.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Poygan clay:

Mechanical analyses of Poygan clay.

Number.	Description.	Fine gravel. <i>Per cent.</i>	Coarse sand. <i>Per cent.</i>	Medium sand. <i>Per cent.</i>	Fine sand. <i>Per cent.</i>	Very fine sand. <i>Per cent.</i>	Silt. <i>Per cent.</i>	Clay. <i>Per cent.</i>
311001.....	Soil.....	0.0	0.9	1.3	3.0	4.1	46.6	44.0
311002.....	Subsoil.....	.4	2.1	1.9	5.2	7.7	37.9	44.4

The following sample contained more than one-half of 1 per cent calcium carbonate (CaCO_3): No. 311002, 13.84 per cent.

POYGAN FINE SANDY LOAM.

The surface soil of the Poygan fine sandy loam consists of a dark-brown to black fine sandy loam, about 12 inches deep. In many places this is underlain to a depth of 24 to 48 inches by a reddish-brown sandy clay, which in turn rests upon a red clay. The subsoil is, however, variable, and in some places consists of gravel mixed with yellowish clayey sand resting on red clay. The gravelly stratum varies in thickness from a few inches to several feet.

Areas of this type are of small extent and confined to the basin surrounding Lake Winnebago. It all occurs just southwest of Calumetville, and the total area is less than 1 square mile.

The topography is level to gently undulating and drainage over most of the type is well established. In spots where the clay lies near the surface tile drains could be used to advantage. The type in part represents a glacial lake deposit and in part an old beach line.

The greater part of the Poygan fine sandy loam is cultivated, giving good yields of the general farm crops. Corn averages about 50 bushels, oats 40 bushels, barley 35 bushels, and rye 20 bushels per acre. The type is adapted to a wide range of crops. Many truck crops could be successfully grown.

CARRINGTON SILT LOAM.

The surface soil of the Carrington silt loam consists of a black to very dark brown, smooth-textured silt loam, about 12 inches deep, containing a comparatively large quantity of organic matter. The subsoil consists of a dark-brown silt loam, becoming lighter in color with depth and grading into a yellowish brown or sometimes yellow below 18 inches. The clay content gradually increases until at 20 to 30 inches it becomes a heavy silty clay loam. At a depth of 3 feet or more fine sand is sometimes found with the heavy material in small amounts.

A well-marked variation in the type is found associated with areas of the Clyde silty clay loam. This represents differences in the weathering of the surface and subsoil. Where the ground-water level is lowered, so that the bluish-drab subsoil of the Clyde silty clay loam is exposed to the oxidation and weathering of the atmosphere, the color gradually changes to a yellow and the soil approaches more nearly a heavy phase of the Carrington silt loam. In places the surface of the Carrington silt loam may contain a noticeable quantity of fine and very fine sand, although this is the exception, as the type as a whole is very uniform. The depth of soil to bedrock is not as great as in the Miami silt loam, varying from 2 to 10 feet, with occasional outcrops. The deep subsoil contains some gritty material, gravel, and a few stones.

The Carrington silt loam is one of the most important soils in the county and ranks next to the Miami silt loam in value. It is confined to the western part of the survey and the most extensive developments are found in the country between Ripon and Waupun. Associated with the type are areas of the Miami silt loam and some Carrington gravelly loam.

The topography is level to undulating and in places gently rolling. The type is more nearly level than the Miami silt loam in the western part of the area. There are no steep slopes and erosion is not a problem of importance. Rarely is any Peat or Clyde silty clay loam found associated with the Carrington silt loam where the surface is level. A few marshes occur over the rolling areas. Natural drainage is fairly good over most of the type, although in a number of sections, especially where the surface is nearly level, the underdrainage could be greatly improved by tiling. Areas of level surface and overlying bedrock at shallow depths are often droughty during dry spells and slow to absorb soil moisture after heavy rains. Unless the subsoil is several feet deep over bedrock, which is in places broken or fissured, there is often a lack of moisture when the rainfall is not well distributed. Tile drainage has not been practiced to any extent in this type, but it should be given a trial, as it would doubtless improve the moisture conditions.

In origin the Carrington silt loam consists of a loesslike material deposited over the till of the ground moraine. The lower part of the soil section has the true till character, lacking stratification and containing some coarse material, but the surface is very silty, free from coarse particles and similar to loess in structure. The dark color of the soil is due to the accumulation of vegetable matter. While the glacial material from which most of the type is derived contains fragments of limestone, rests upon limestone, and is probably largely composed of this rock ground to a powder, the surface contains but little carbonate of lime, and an acid condition prevails over much of the type.

The Carrington silt loam is one of the leading types in the county and a larger proportion of it is under cultivation than of any of the other soils. The areas are highly improved and appearances indicate a thrifty condition of agriculture. Dairying in conjunction with general farming is the prevailing type of farming. Hogs are also raised quite extensively.

The crops consist of corn, oats, barley, hay, some wheat, and a little alfalfa. For small grains the type hardly equals the Miami silt loam in the quality of the grain produced, although the yields are about the same. The Carrington silt loam is better adapted to corn than the Miami silt loam and it is probably the best corn soil in the area at the present time. Corn yields from 35 to 80 bushels

per acre, oats from 35 to 70 bushels, barley 25 to 45 bushels, wheat 15 to 30 bushels, and hay from 1 ton to $2\frac{1}{2}$ tons per acre. Alfalfa is grown to a limited extent and yields from 2 to 4 tons per acre. Considerable variations occur in the yields, owing largely to differences in farming methods.

The cultivation of the type is easy if plowing is done under proper moisture conditions. Many farmers plow in the fall, although the type can be worked earlier in the spring than the Superior, Keweenaw, and Poygan soils. A good mulch can be readily obtained in soils of such silty texture. The subsoil is retentive of moisture, and where the underlying rock is not too close to the surface the type resists drought fairly well. As the dairy industry is well developed, there is a good supply of manure, which is applied at the rate of 10 to 15 loads per acre every four or five years. The application of ground limestone to correct acidity is being tried by a few farmers, but the practice has not as yet become general.

The rotation most commonly followed consists of corn, barley, oats, and hay. Wheat was at one time the leading crop, but is grown now only to a limited extent and in some communities is not sown at all.

Among the special crops grown sugar beets may be mentioned. The type is well adapted to their production, and yields of 10 to 15 tons per acre are obtained. Tests as high as 17 per cent have been obtained, but this is above the average. Cabbage is grown extensively in the vicinity of Waupun, where it is made into sauerkraut. Peas for canning are also grown here. Around Ripon cucumbers are grown extensively for the pickle factory located at that place. Raspberries, blackberries, and strawberries do very well, from \$200 to \$300 per acre being sometimes realized from such crops, although not grown on a large commercial scale. Potatoes are grown mainly for home use, though many farmers have some to sell each year.

In the methods of cultivation followed, crop rotations practiced, and in the general conditions existing the Carrington silt loam is comparable with the Miami silt loam. The two types form the most extensive and best agricultural region in the county.

The two most important problems in connection with the improvement of this type are the correction of soil acidity and the establishing of tile drains where drainage is defective. The acidity can be corrected by acreage applications of 1,500 to 2,000 pounds of ground limestone, of which there is an unlimited source of supply in the county. Cooperation among the farmers would enable them to purchase a crusher and prepare the rock for their own farms. Tile drains are not at all common on the type, but there is considerable land which could be improved by their use.

Farms on the Carrington silt loam sell for \$75 to \$150 an acre, depending on the location and improvements.

CARRINGTON GRAVELLY LOAM.

The Carrington gravelly loam consists of a dark-brown or nearly black silt loam, extending to a depth of 4 to 8 inches, where it grades into a gravelly loam or gravelly clay loam containing boulders and limestone fragments. In places a bed of gravel or sand is found at a depth of 2 feet. The underlying rock outcrops in places, though the till may have a depth of nearly 20 feet. Where the bedrock is near the surface angular limestone fragments are more numerous on the surface. Where the till is deeper the stones on the surface are more rounded and more often of crystalline rock.

The Carrington gravelly loam occurs on the tops of long, narrow ridges, kames, and steep slopes and is confined to the western part of the county, where it is always associated with the Carrington silt loam. Frequently small knolls from 5 to 10 rods in diameter and from 5 to 20 feet high are found. Such areas, because of their small size, could not well be indicated on the soil map.

On account of the position occupied by this type its natural drainage is thorough and sometimes excessive, especially where the soil is shallow or the subsoil is filled with rock fragments or gravel. On the steeper slopes erosion is severe and care is necessary if washing is to be prevented.

The type is of glacial origin, the rock cores found in many of the hills and knolls representing remnants of preglacial erosion.

The type constitutes a part of the prairie section and was not originally forested, except, perhaps, over very small areas.

Where rock lies close to the surface the type is of little value for cultivated crops, and small areas of this sort in many places break the fields and cause inconvenience in plowing. Where there is a good covering of soil and the rock fragments are not too numerous fair crops are grown. The yields on such places in some seasons equal those from the Carrington silt loam, though taking the type as a whole the yields are considerably lower. Alfalfa could be grown where the soil is deep, as the drainage is excellent. The type is not as likely to show an acid reaction as is the Carrington silt loam.

CLYDE SILTY CLAY LOAM.

The surface soil of the Clyde silty clay loam, to an average depth of 10 inches, consists of a dark-brown or black clay loam, containing considerable silt and having a high content of organic matter. The subsoil consists of a drab or bluish colored, heavy, plastic silty clay loam. Throughout the drab subsoil are found yellow iron segregations.

tions. These become more numerous with depth and in places are so thoroughly disseminated as to give the material a yellow color. In the lower subsoil a small percentage of fine and very fine sand is usually present.

Included in the type are some areas of lighter texture, as in section 27, Taycheedah Township, where the surface is a dark-brown loam, underlain by a bluish or yellowish plastic clay. The subsoil becomes gritty in the lower depths and sand is often found at 24 to 30 inches. Where the type is associated with areas of the Miami sandy loam or other sandy types there is more sand in the soil than typical. In the northwestern part of section 32, Auburn Township, is an area of sandy loam a few rods wide, where the surface is nearly black and where the subsoil grades into a gritty clay loam at 16 inches. The heaviest phase of the Clyde silty clay loam is found to the west and north of Oakfield, where it is associated with and closely related to the Poygan clay. Over this area the red-clay deposit giving the Superior soils is sometimes found at a depth of 28 to 30 inches, though it is very generally mottled with blue and yellow. This condition usually occurs wherever the Clyde soils are associated with the Superior or Poygan soils.

The Clyde silty clay loam occurs in all parts of the county. It occupies depressions and low-lying areas within the other types. It is found quite commonly along stream courses, in places where the accumulation of organic matter has not been sufficient to form Peat or Muck. The largest area lies west and north of Oakfield, in the basin once occupied by an extension of Lake Winnebago.

The topography is level to undulating. The natural drainage is poor and artificial means must be employed before large crops can be obtained.

The soil has been formed in old glacial lake basins, ponded valleys, and kettle holes carrying accumulations of organic matter but not sufficient to form Peat or Muck. This type has been modified in places by soil material washed from higher-lying areas. Some of the areas occurring along streams may have received a variable amount of alluvial material deposited from flood waters, but for the most part this influence was not considered to be of sufficient importance to constitute the type a true alluvial soil, and such areas were included with the Clyde silty clay loam, as being of about the same agricultural value.

The native vegetation consists quite generally of grasses and sedges, especially where the land is wet most of the time. On other areas elm, ash, poplar, and willow are found.

Only a small percentage of the type has been put under cultivation. The largest tilled areas are found north and east of Oakfield, where the drainage conditions have been improved by digging ditches and

where the land is somewhat higher. Some of the type west of Oakfield has also been improved. Aside from these areas most of the soil is too wet for cultivation in years of normal rainfall. Where the land is properly drained excellent crops are produced, the type being especially well adapted to corn and grasses. Corn yields 50 bushels per acre, and from 70 to 80 bushels are sometimes obtained. Timothy and alsike clover do well. Small grains produce too rank a growth of straw and are apt to lodge. Sugar beets grow luxuriantly and yield from 15 to 18 tons per acre. While the sugar content is relatively low, the yield per acre is usually higher than on the Miami silt loam. Other crops, such as cabbage and onions, while not grown extensively in the county, are profitable crops on similar soils in other places and might well be introduced here. At present the larger part of the type is used for marsh hay and pasture.

Before any extensive utilization of the type will be possible it must be drained. Up to the present time attention has been given to surface drainage only, except in a very few cases. Streams must be straightened and their channels deepened. Tile drains should be installed wherever necessary. It is estimated that this can be done at a cost not to exceed \$25 to \$30 an acre.

Land of this type varies in value from \$10 to \$100 an acre, depending upon location and drainage conditions. The average price is about \$25 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type.

Mechanical analyses of Clyde silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
311019.....	Soil.....	0.8	1.2	0.6	1.5	9.0	59.8	27.0
311020.....	Subsoil.....	.3	.9	.6	1.3	11.6	58.7	26.5

CLYDE SILT LOAM.

The surface soil of the Clyde silt loam, to an average depth of 10 inches, is a dark-brown to black silt loam, having a high content of organic matter. The subsoil consists of a drab or bluish silty clay loam, becoming heavier with depth. Like the other heavy types of the series, the subsoil contains a great many yellow iron segregations. These become more numerous with depth, and in places are very abundant.

There are only a few occurrences of the type in the county. These are all located in the central part, occurring in a discontinuous curved belt around the outer border of the Poygan clay and in

rather intimate association with the Clyde silty clay loam. It occurs in low-lying areas where the drainage is poor, where organic matter has accumulated in the surface soil, and where the subsoil has not been well aerated.

Up to the present time the agriculture has not been different on this type from what it is or has been on the Clyde silty clay loam. To all intents and purposes, therefore, the description of the treatment of the soil and the crops grown, as well as those best adapted to the soil, suggested for the latter soil will apply to this. The only difference is the slightly lighter texture of the Clyde silt loam.

CLYDE FINE SAND.

The material mapped as Clyde fine sand consists of a black fine to very fine sand, in places approaching a silt, underlain by a light-colored, yellowish sand of nearly the same texture, and extending to a depth considerably below the 3-foot section.

The Clyde fine sand is of limited extent and confined to long, narrow areas running parallel with or bordering the present shore of Lake Winnebago.

The topography is level, the type occupying ridges only a few feet above the adjoining soils. The water table is close to the surface, and for this reason crops do not suffer during times of drought. The soil is sometimes excessively moist following spring rains.

The type represents a beach deposit formed when the lake was at a higher level than at present.

Within the city of Fond du Lac this type is used for building lots. Out of the city it supports some trucking with good results. Some of the general farm crops are also grown. The type is of little importance from an agricultural standpoint.

PEAT (WITH INCLUDED AREAS OF MUCK).

Under the term "Peat" have been included the low-lying areas where there has been a considerable accumulation of organic matter in the presence of water, which is now found in various stages of decomposition. The layer of organic material varies in thickness from 1 to 10 feet or more. It may be a cinnamon-brown or dark-brown, fine, powdery material where well decomposed and dry, or a raw, fibrous mass where in the earlier stages of decomposition. By far the larger proportion of the Peat in this county lies between these two extremes, showing to some extent its fibrous nature, but having lost some of its original structure. Areas such as those found at the foot of Lake Winnebago and around Mullet Lake represent true marsh conditions, where there is a floating mass of vegetation, but where the accumulation has not proceeded far enough to result in

the formation of beds of Peat. Included with the Peat areas are small patches of Muck, where the material is more thoroughly decayed and the content of mineral matter is higher. These areas are not of sufficient size to be shown on the map.

Peat (with included areas of Muck) is distributed in areas of varying size throughout the county. The largest bodies lie in Marshfield, Forest, Osceola, Auburn, Eldorado, and Lamartine Townships, in each of which the type covers several square miles. The surface is level and the natural drainage is poor. But few efforts have been made so far to reclaim the land.

Peat (with included areas of Muck) has been formed in glacial lake basins, kettle holes, and ponded valleys. The decomposition of water-loving plants, retarded by the presence of water, has favored the accumulation of organic matter, which in time has formed the Peat. Two varieties of Peat beds were noted. Those derived from the decay of grasses and sedges are usually black in color, while those derived from mosses (chiefly sphagnum moss) are largely of a cinnamon-brown color. As Peat is made up very largely of organic matter it is very rich in nitrogen, but usually deficient in phosphorus and potash. Litmus tests show that some of the areas are acid and that others are not.

The native vegetation on Peat (with included areas of Muck) varies. In the western part of the county there are, in addition to grasses, sedges, and mosses, some willow, elm, poplar, cattail, and other water-loving plants. To the east of the escarpment there are many areas covered with tamarack and white cedar. It is a noticeable fact that within Fond du Lac County there are no tamarack trees in the Peat areas west of the escarpment.

With the exception of narrow strips along the edges of some of the marshes practically none of this type is used for agricultural purposes other than for pasture and hay. Drainage will be necessary before these areas can be utilized. A large part of the land has sufficient fall to make drainage feasible. In some instances it would be necessary to lower the water in nearby lakes or mill ponds.

In other parts of the State and in other States Peat when drained has been made to produce very good yields of a number of crops, including corn, cabbage, onions, beets, potatoes, peppermint, etc. The quality of the potatoes and beets is not as good as on upland soils. Small grains do not do well as a rule, for there is too rank a growth of straw and the grain is apt to lodge. Grasses make a rank growth and heavy yields of hay. A mixture of timothy and alsike gave a large yield of hay of good quality. Celery might be grown successfully here as in other places, and there are a number of other crops which could be introduced. The best general farm crops for Peat are hay and corn.

Because of the small amount of inorganic matter in the soil and the consequent lack of potash, some potash fertilizer used on the Peat gives good returns and pays better than manure. The organic matter of the manure is not needed, consequently it is advisable to use the manure on the upland and commercial fertilizers on the Peat. Good results have been obtained by scattering some of the upland soil on the Peat.

The selling price of the Peat (with included areas of Muck) ranges from \$5 to \$25 an acre.

SUMMARY.

Fond du Lac County is located in the east-central portion of the State of Wisconsin and comprises an area of about 734 square miles, or 469,760 acres. The county has a population of 51,610. The city of Fond du Lac, with a population of 18,797, is the county seat, an important railroad and manufacturing center, and the largest local market in the county.

Three important railroad systems enter the county and provide excellent transportation facilities. Fond du Lac is 159 miles from Chicago over the Soo Line.

The mean annual temperature is 44.6°, the rainfall 27.84 inches, and the snowfall 28.7 inches. The winters are severe, but the growth of all vegetation during the summer months is rapid. The average length of the growing season is 150 days.

Dairying, in conjunction with general farming, is the type of agriculture most extensively followed at present. The products are chiefly butter and cheese. The leading crops are oats, barley, corn, and hay. Alfalfa is being successfully grown and the acreage is increasing. Wheat and rye are raised to a limited extent. Such special crops as potatoes, sugar beets, cucumbers, cabbage, and peas for canning are successfully grown, though not on a very extensive scale.

Of the land in the county 95.8 per cent is in farms and of this 72.5 per cent is improved. The average size of farms is 105 acres and 80.2 per cent of all farms are worked by the owner.

Agriculture in Fond du Lac County, as a whole, is highly developed. The extension of tile drainage and the use of lime in some form are suggested steps for further improvement.

The soils of the county are all derived from glacial and lacustrine material and owe their differences largely to the varying agencies of deposition and to the character of the morainic topography of the county in which they are found. Eight distinct soil series and 17 soil types were recognized and mapped.

Of these the Miami is the most extensive and important series. The silt loam is the most important type of the series. It is a good general farming soil and well adapted to all the farm crops common to the

region. The gravelly loam where sufficiently deep produces yields nearly equal to the silt loam, but the shallow areas suffer at times from drought. It is considered a fair soil. The Miami sandy loam is of small extent and found chiefly in the southeastern part of the county.

The Fox silt loam is a good general farming soil and all the ordinary farm crops of the region are grown upon it.

The Rodman gravelly sand and Rodman gravel are of limited extent and of little importance agriculturally.

The Superior series is derived from both lake-laid and ice-laid material, and is represented here by two types. The silty clay loam, till phase, is quite extensive, highly developed, a good general farming soil, and well adapted to dairying. Portions of it should be tile drained. The gravelly loam is of limited extent and of little importance agriculturally.

The Kewaunee clay loam is derived from ice-laid glacial deposits. In crop adaptation and cultivation it is very similar to the Superior silty clay loam, till phase.

The Poygan series is closely associated with the Superior soils and is of the same origin, but the deposits have been modified by the accumulation of organic matter. The clay is naturally a productive type, and yields on it could be materially increased and all the type brought to a high state of cultivation if tile drains were generally installed. The fine sandy loam is of very small extent.

The Carrington series embraces the dark-colored, glacial prairie soils. Some of the most highly developed land of the State is composed of these soils. The silt loam type is extensively developed in the western part of the county. It is a good general farming soil and supports a well-developed dairy industry. Portions of the type are in need of tile drainage and applications of lime. The gravelly loam consists of small knolls and rounded hills over which the soil is shallow and often filled with limestone fragments.

The Clyde series occupies old lake beds, ponded valleys, and other minor depressions, in which there is an accumulation of some organic matter, but not enough to give a Muck or Peat. The silty clay loam is in need of drainage. When properly drained it will make a very productive soil. The silt loam is of limited occurrence, and up to the present time the agriculture on this type has not been different from what it is or has been on the silty clay loam. The fine sand represents an old shore line of Lake Winnebago. It is of small extent and of little importance.

Peat (with included areas of Muck), essentially an organic soil, occupies old lake beds, ponded valleys, and the valleys along streams. It is all poorly drained, and but few attempts have been made to reclaim it.



[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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SOIL
PROFILE

(3 feet deep)

Miami
gravelly loam

Sil

Sicl

Sil

Sicl

Sil

Miami
sandy loam

Sil

Sil

Sicl

Sil

Sicl

Sil

Deep phase
Clyde
fine sand

Fs

Fs

Clyde
silty clay loam

Ci

Sicl

Clyde
silt loam

Sil

Sicl

Rodman
gravel

Fs

Gr-s

Rodman
gravelly
sand

Fs

Fs

Superior
gravelly
loam

Sil

Ci

Superior
silty clay loam
Till phase

Sid

Ci

Carrington
gravelly
loam

Sil

Ci

Carrington
silt loam

Sil

Sicl

Poygan
fine sandy
loam

Fal

Sc

Poygan
clay

Ci

Fox
silt loam

Sil

Sicl

Keweenaw
clay loam

Sil

Ci

Legend

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

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Gravel

Clay

Peat
(With water-soluble
organic material)

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Rock outcrop

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Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
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P

Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

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Rock outcrop

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Silt loam

Sandy loam

Sandy clay

Fine sand

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Clay

Peat
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Rock outcrop

Sil

Silt loam

Sandy loam

Sandy clay

Fine sand

Gravel

Clay

Peat
(With water-soluble
organic material)

P

Rock outcrop